VOL. X, PP. 45-92. NOVEMBER 20, 1894.

PROCEEDINGS

OF THE

American Forestry Association

AT THE

Tenth, Eleventh, and Twelfth Annual Meetings,
Washington, December, 1891, 1892, and 1893,

AND AT THE

World's Fair Congress, Chicago, October 18 and 19, 1893.

VOLUME X,
pp. 45–92.

WASHINGTON, D. C.:
1894.

NOTICE.

This is the second fascicle of Vol. X of Proceedings, comprising pages 45 to 92.

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THE RELATION OF FORESTS TO CLIMATE AND HEALTH.

By Cleveland Abbe.

[Read at World's Fair Congress, Oct., 1893.]

The surface of our globe is about four-fifths water and one-fifth land. Of this land one-fifth is now or was covered with forests before man destroyed them. We have therefore to recognize the fact that only one-twenty-fifth, or four per cent. of the surface of the globe, is naturally covered by forest areas, and that these can therefore exert a relatively small and not a preponderating influence on the general condition of the atmosphere.

On the other hand, the areas that would naturally be covered by forests are precisely those in which man loves to dwell. The trees afford him shade, food, and lumber, and their decayed vegetation has covered the naked, barren clay, gravel, sand, and rock, with a vegetable mould in which he can raise the plants that he needs for food and clothing. Undoubtedly, man may be properly considered an animal adapted to live in groves and forests, and in clearings in the midst of the forest. He was not originally an arctic animal, nor an aquatic creature, nor a denizen of the prairie; but from his natural history we can safely infer the correctness of the Mosaic record, which asserts that our ancestry began among the trees of the Garden of Eden. There is an intimate relation between the forests of the world and the migrations and development of the human race. Although the forests may not affect the atmosphere or the average climate of the whole earth to any great extent, and although their very existence depends upon certain broad climatic conditions over which they have no control, yet within a certain limit they produce a local climate of their own which is extremely favorable to the prosperity of mankind. Barbarian tribes have always sought the forests as a home, civilized man has destroyed the forests; a higher civilization teaches us to restore them.

Meteorological Influences of Forests.

The actual difference between the climate in a forest region and that which would exist were the forest cut away gives us a proper

measure of the influence which that forest has exerted by its presence in modifying the local climate, and it is this local modification that we are interested in.

1. The temperature of the soil and its drainage water is on the average much lower within the shade of a forest than in the open sunshine, and this effect is greater as the forest is denser; the mid-day temperatures and the mid-summer temperatures of the air within a forest are reduced much more than the night and winter temperatures are raised. In general it is even so much warmer under the forest at night-time that frost cannot occur on the surface of the ground in the early morning hours.

2. In the daytime the mean temperature of the air in the tree-tops is rather higher than at the same height above ground in the open fields. The mean temperature below the tree-tops at four or five feet above the ground is lower in the forest than at the same height over open fields. Again, the mean temperature at considerable heights above the tree-tops is somewhat higher than at the same total height above ground in an open region. Evidently the sunshine caught by the leaves and branches of the crown of the tree warms up not only the crown but the air above it to a less extent, but very much as if the surface of a meadow had been raised to the level of the crown of a similar tree. A similar condition exists when the earth is shielded from sunshine by the clouds and fog. Just as the surface of the ground is hotter than the soil beneath or the air above, so the crown of a forest is warmer than the air below and the air above it. A small fraction of the slightly higher temperature within a forest may also be due to the heat given out by the chemical processes involved in the growth of trees.

3. *Humidity.*—Within the forests the quantity of moisture thrown into the air by transpiration from the leaves is far greater than the evaporation from a water surface that is not exposed to wind and sunshine; but under the influence of wind and sunshine the transpiration from the leaves is less than the evaporation from a water surface. The evaporation from a saturated bare soil in the cool shades of the forest is about the same as from a water surface in the same position as to wind and sunshine. The total quantity of moisture returned into the atmosphere by transpiration from the trees and by evaporation from the soil of a forest is about 75 per cent. of the precipitation, whereas the evaporation from the same soil when away from the forest is scarcely 30 per cent. of the pre-

cipitation. Therefore the tendency of a forest is to increase both the absolute and relative humidity of the atmosphere; forests of evergreens have two to four times the influence in increasing the relative humidity than forests of deciduous trees.

4. *Rain and Snow.*—Some have maintained that at stations within a forest the rainfall is actually larger than at points beyond the forest influence; personally I believe that although the quantity of rain caught in the gauges may be larger, yet this excess is principally due to the absence, at the forest gauges, of such strong winds as prevail in the open fields: a strong wind diminishes the catch of the gauge (unless the mouth of the gauge be protected), but does not diminish the true rainfall itself. On the other hand, the tendency of the loose soil of the forest is to absorb and retain much more moisture than is held by the firmer soil of the open prairie; therefore both the texture and the temperature of the soil conspire to enable it to retain a large proportion of the rainfall. Moreover, the snow that is protected by the forest from the sunshine and wind is thereby prevented from melting and evaporating rapidly. The annual evaporation at the surface of the ground is about 12 per cent. of the rainfall within the forest, but about 40 per cent. in the open field. We see, therefore, in every respect the tendency of a forest to conserve the rainfall. It not only shields it from evaporation and uses less of it for the growth of the forest than would be used in the growth of grasses or herbs, but it conserves what is left in the forest soil so as to diminish, or at least regulate, the drainage into the river basins, thereby diminishing the danger of destructive floods.

5. What we have said with reference to the temperature and moisture of the soil and the air within a forest applies to a less extent to the influence of the forest on the climate of the neighboring country. Stations located in small clearings or openings, or forest glades, are of course most influenced by the surrounding trees. Stations on the windward side are more influenced than those on the leeward side. Dense forests have a stronger influence than the lightly forested country. Forests in regions where light winds prevail have a greater local influence than those in the regions of strong winds. Forests located on mountain sides and highlands have an influence on the temperature and moisture of the country below them. The cool and moist air of the forest, by settling downwards in the daytime, although it is warmed dynamically as well as by isolation, still preserves a lower temperature and a

higher humidity than would have prevailed in the case of no forest. In the afternoon hours this influence of the forest air may become so great as to have an appreciable effect in slightly increasing the intensity and frequency of the local thunder-storms. The so-called vertical gradient of temperature, or the diminution of temperature per hundred feet of ascent, must be 0.55 degrees F. or more per hundred feet when the lower atmosphere is in the condition that is called stable equilibrium. This condition of stability always prevails within the forest on a horizontal plain, so that storms do not originate within it, but the relation of the forests on the mountain sides to the air of the valley below may easily be such that in the daytime instability exists and the cool forest air descends, pushing up the hot air of the lower valley until a cloud and rain or thunder-storm is formed. On the other hand, at night-time this same forest keeps its air from whirling rapidly, and therefore will not send the air down to the cold valley below. Therefore the influence of forested hilltops is quite the opposite to that of the naked surfaces of stony peaks and bare fields of deforested areas, whose heated surfaces send up hot air by day and send down cold air by night. Thus the effect of the forest-covered mountains is to diminish the cold night winds and the hot day breezes in the valleys below and to favor the formation of local cloud and rain in the valleys.

As the air that flows down the mountain side during the night from a forest has a higher dew-point and a lower temperature than that which flows down from an unforested surface, therefore a less amount of cooling will cause it to form fog; hence the crops in the valley are more likely to be sheltered by the fog from dangerous frosts.

During the night-time the air within a forest is warmer than that above it, and the so-called stable equilibrium slowly rises, while the cooler air above percolates downwards through the leaves. If the forest is in a level plain or at the bottom of a valley, then this interchange is a very slow process, and no sooner does the warmer, moist air ascend and mix with the cooler air above the tree-tops than its temperature begins to cool enough to form a fog in the early morning hours over the forest instead of beneath the forest as when the latter crowns the mountain-top. By this formation of fog the forest again shows its ability to favor the retention of its heat and prevent injurious frost.

On the leeward side of a forest the effect of the circulation or

interchange of the interior and exterior air is appreciable for a short distance, especially in the summer-time. The most interesting forest influence on the leeward side is that which it exerts by virtue of its action as a wind-break; but for this purpose a forest is scarcely necessary, since the few rows of tall trees or a small woodland break up the power of the strong winds of our prairies. It has, in fact, been customary to plant rows of trees running north and south so as to break up the cold, dry, west winds without cutting off too much sunshine from the soil. A series of wind-breaks may be considered as a forest that has been thinned out until it has become a series of clearings or glades. Within such glades we have less wind, therefore there is less evaporation from the soil, therefore the temperature of the soil is higher and its moisture is greater; similarly, the temperature of the air is higher, and all these conditions favor the growth of plants. On the other hand, these same conditions also increase the liability to injurious frosts during still, clear nights, and more especially because the increased heat of air and soil in the daytime stimulates the plants to a more rapid and delicate growth, that is more easily injured by frost; but this latter danger is again set off by the increasing tendency to form protective fogs.

The protection that a forest offers as a wind-break to the adjoining fields on its leeward side is effective not only by diminishing the force of the wind, but by the consequences that flow from this latter action. A diminished wind means that the sluggish moving air shall be warmed up in the daytime by contact with the ground, much more than would be the swiftly moving air when the wind-break is absent. This reacts upon the ground itself, so that as a consequence both soil and air are warmer.

The evaporation from the surface of the soil is also greatly diminished, in consequence of which not only does the soil retain more moisture, but it is also warmer than it would be under the influence of a strong wind. At the same time, the air above the soil acquires a higher percentage of relative humidity. For both these reasons the plant has more water at its disposal stored in the earth, while the leaves, apparently, are in less need of water and transpire less. In this manner a wind-break contributes to preserve the plant against droughts. A double row of tall trees 500 feet apart, running north and south, has a sensible effect and will effectually protect a large area.

Not only is the soil kept slightly warmer, but it is even prevented

from freezing, and, in addition to this, the snowfall is distributed so much more evenly in the lee of the wind-break that, when it melts, a much more uniform amount of moisture soaks into the warm, porous, unfrozen soil.

The forests upon a mountain side exert an indirect influence in increasing the quantity of moisture that eventually reaches the ground, but one that is only appreciable when the forests are themselves involved in the clouds which form high up on the mountain side. These clouds, which, to a distant observer, seem stationary and attached to the mountain, are really permeated by strong winds, and every globule of moisture that helps to make up the cloud is being rapidly carried by the wind from one side of the cloud to the other. The little globules become visible on the windward side of the cloud, they grow a little larger, then begin to diminish, and by the time they reach the leeward side they have evaporated and disappeared entirely. Meanwhile many of them have struck the mountain side; the rocks are everywhere moist with them; the leaves and the branches are dripping, and so far as this drip soaks into the ground it abundantly serves the place of an ordinary rain, which, by its continuance hour after hour and day after day, maintains the mountain side in a state of perfect verdure. This drip of the trees gathered from clouds and fog goes far to maintain the woodlands of Maine and Maritime provinces of Canada. It supports the rare orchids on Table Mountain and the lichens on the black rocks of Pungo-Andongo and gives to the Island of Ascension its beautiful Green Mountain. But this mechanical action by which the leaves catch the floating globules of the cloud is, of course, also a very local action; nevertheless, it is extremely important, since by this process all the mountains of the world might be covered with forests without the help of rain. By this process the presence of forests in the cloud region itself determines a slight increase of catch of moisture, and this increase is larger for forests than for the bare rocks and soil, although it is appreciable even for them. Evidently, the catch depends directly upon the area of the leaf surface and the velocity of the wind. I estimate that on the summit of Green Mountain the leaves, against which the clouds are driven with little intermission, night and day, catch an equivalent of one inch in depth of rainfall daily; but it must be remembered that this so-called drip covers but a very small area of the island and is followed by a very rapid evaporation as soon as the water has descended a few rods below the dripping

trees. This really enormous catch is paralleled by the great growth of frost work in the winter season on Mount Washington and other summits. The correspondingly enormous loss by evaporation within a few minutes after the water is caught makes this form of precipitation almost useless for agricultural purposes; it is as though one perpetually washed the leaves without wetting the roots.

The ability of the forest soil to hold a large quantity of moisture is peculiarly important when the trees have overgrown the moraines of boulders and gravel left by recent glacial action. The best illustration of this is found in the forests from Maine to Labrador. Here the soil is often only a mass of large boulders, on and between which lichens and mosses first grew in the days when the surface of the ground was higher above the sea-level than it now is. Into this mass of hard rock and fine vegetable mould the roots of the great forest trees deeply penetrate, and this matrix affords all the mechanical support and liquid nourishment that is needed. This matrix covers the land to an average depth of five feet; the volume of the spongy matter contained therein is equivalent to an average depth of 1½ feet, while the volume of the rock is equivalent to a depth of 3½ feet. The volume of water that can be absorbed by the spongy soil is fully equivalent to a depth of nine inches. When a forest fire has consumed this spongy soil and left little else than naked boulders, a hundred years is needed to even partially replace this loss, and meanwhile the falling rain-water drains rapidly away, producing floods in the rivers and leaving the land exposed to droughts. To preserve our forests is to preserve this precious water for the use of animals, plants, and men.

Hygienic Influences of Forests.

The relations of forests to the biologic and hygienic conditions in their immediate neighborhood are, I believe, only beginning to be realized, and I would express my conviction that in hygienic matters the forests have an influence that extends far beyond their immediate neighborhood, and that is far more subtile and more important to the human race than are their purely meteorological or physical influences. The word "climate" is used in two very different senses by the meteorologist and the sanitarian. To the former it means the characteristic combination of temperature, moisture, sunshine and rain, wind and pressure; but the sanitarian adds to all this a very important property of the atmosphere which is not

generally considered by the meteorologist—namely, its power to carry from place to place those minute particles of dust and those minute living germs of disease which often decide as to the habitability of any place and affect the development of the human race as much as do the meteorological elements.

It seems to have been abundantly demonstrated that mankind flourishes when the atmospheric conditions are uniform, as also when the regular diurnal and annual changes, no matter how severe they are, can be clearly foreseen and provided against. It is the irregular, sudden, or the so-called non-periodic and almost abnormal changes, especially of temperature and moisture, that are injurious to the human race, and the more so in proportion as they are unforeseen and cannot be suitably provided for. This leads me to remark that the great development of the modern weather bureau, with its telegraphic predictions of blizzards, cold waves, frosts, rains, and storms, which are now so common in every civilized nation throughout the globe, has done quite as much to ameliorate the hygienic conditions of mankind as it has done to benefit the agriculturist or to save life and property at sea. The modern weather bureau is one of the most beneficial applications of human knowledge. From many points of view every living being depends upon the atmosphere for his prosperity, and needs to be forewarned of its occasional irregularities. Therefore, while we give a few minutes to consider the influence of forests in ameliorating the hygienic effects of a variable climate, we must also bear in mind that most of the unpleasant features can now be largely counteracted by a proper use of the observations and predictions of the daily weather map.

A sudden fall in temperature—and in the United States we sometimes have a fall of 40 Fah. within an hour—is, of all meteorological phenomena, the most fatal to human health and life, and especially when it is accompanied by high wind and a blinding snow or sleet or rain. Cold waves of this kind sweep over Texas and Florida and eastward to Maine; similar cold blasts, known as the bora in Southern Russia and as the buran in Siberia, sweep over these countries; a corresponding phenomenon is known in China; the pamperos of South America, although not so cold, belong to the same class of winds. Inasmuch as a forest growth does slightly diminish the tendency toward sudden changes of temperature, it has been said that possibly these extended storms could, by the forests, be mollified as to their severity or diminished as to their

frequency; but a more thorough study of the mechanics of the atmosphere and the origin of these winds will, I think, serve to show that this hope is not likely to be realized, since the forest influence is too slight and we must look to the weather bureau to forewarn us of the coming of these cold storms, which, in fact, are able to destroy the forests themselves.

If we except these great atmospheric phenomena, we may say that our forests do favorably affect the atmosphere in its relations to human health and life. The prominent hygienic relations between mankind and forests consist, as I look at the question, in the following particulars, which I need only to briefly mention in order that their importance may be recognized:

1. A forest reserve constitutes the best means of collecting and storing up water for domestic use in cities and for manufacturing purposes on rivers and small mill-streams. A city whose thousands depend on a reservoir of water is brought face to face with epidemic if it is polluted, or with famine and pollution if drought prevails. The only known remedy for this disaster consists in maintaining a forest reserve; artesian wells may do for small communities, but the cool forest alone suffices for the needs of a large population.

2. A forest reserve constitutes the ideal ground for that recreation that is absolutely essential to health and happiness of the Caucasian and Aryan races. The prairie and the ocean must be supplemented by mountains, forests, and lakes if we are to have an ideal globe. Without forests we go back to the condition of China, Persia, Asia Minor, and Turkey. A grove or thinly wooded country gives the natural and the best protection from the too powerful rays and heat of the sun. There are races that have developed under the influence of life on the treeless prairie. Such are the Cossacks, Tartars, and Samoyeds of Russia and Siberia, the natives of the pampas of South America, the Comanches, Sioux, and Esquimaux of North America. There are other tribes that have been built to stand the freest exposure to the hot sun of the tropics, as the African negro; but wherever the higher civilization of the Caucasian race has penetrated it has been necessary for them to avoid the action of the midday sun on the brain and nervous system, and to cultivate thick protection for the head. Our own race, which is now peopling America, must learn to cultivate the conditions that favor life and health; it finds that the forest is a necessity; trees must be planted even in our cities, shade must be provided, and the

eye must be relieved of the blinding glare of the full sunshine; the skull must be protected by turban or hat. The death of John Carver, the first governor of the Plymouth colony, in April, 1621, was a case of cerebral meningitis, following a sunstroke, on the first hot day of the early spring, and has been followed by so many similar cases throughout the Atlantic states that the sunstroke is universally dreaded in this country.

3. There is another class of forests, such as those of the eucalyptus, concerning which it has been maintained that these have remarkable efficiency in absorbing the excessive water from marshy soils, thereby drying up the excess of water and diminishing the intensity of malarial fevers. If this were true, the forests would be peculiarly welcome from a hygienic point of view, but I will not maintain that this proposition has as yet been very satisfactorily demonstrated. I incline to a slightly different explanation of the phenomenon, the tenor of which may be gathered from the following paragraph:

During the past ten years both sanitarians and biologists have become convinced of the profound importance of bacteriology in connection with the health, the disease, and the death of all the forms of animal and vegetable life. The cholera germs spread over Asia and Europe from the polluted waters of rivers; the malarial fever germs in the severe types belong to the marshes and river bottoms that bake in the sunshine of Africa, India, and other hot countries; the malaria of milder types comes from the somewhat cooler climates where the forests have been cut down and the soil turned up with the plow. The typhoid and the yellow-fever epidemics have in some way to do with high temperature and soil and water, but nowhere have the bacteria that are injurious to man been found flourishing in the oceans or the forests. We have indeed in the forests many forms of decomposition going on; moulds and fungi abound, but these all flourish in diffused light or darkness, and at low temperatures, and do not spread very rapidly or far owing to the feeble winds within the forest.

It would seem that the higher forms of bacteria, which alone can live and do injury at a temperature of 104 Fahr. within the human body, do not thrive at the low temperatures prevailing in forest soil, although they may possibly exist there; but when this soil is washed down to muddy flats and baked in the sunshine, or when the forest is cut down and the land cultivated by the farmer, who welcomes the sunshine as his friend, then the hot surface soil be-

comes the very nidus that is needed for this form of bacterial development. Just as a field or a city park strewn with stable manure too often gives up to the winds the bacteria of diphtheria and spreads that fearful scourge, so do the ploughed fields of a fresh clearing in the woods give up the germs of malaria to the winds, and they are thus carried to the greatest distances. Who does not know of the sickness that pervades the communities that live on the leeward side of swamps and river flats?

As I write these lines my eye lights on the following paragraphs by Stanley in his "Darkest Africa" (Vol. II, p. 31):

"While we have travelled through the forest region we have suffered less from African fevers than we did in the open country between Mataddi and Stanley Pool.

"A long halt in the forest-clearing soon reminds us that we are not yet so acclimated as to utterly escape the effects of malaria. But when within the enclosed wood our agues are of a very mild form, soon extinguished by a timely dose of quinine.

"If there is a thick screen of primeval forest between the dwelling-place and a large clearing or open country, there is only danger of the local malaria around the dwelling, which might be rendered harmless by the slightest attention to the system; but in the open country neither a house nor a tent is sufficient protection, since the air enters by the doors of the house, and under the flaps and through the ventilators, to poison the inmates.

"Hence we may infer that trees, tall shrubbery, a high wall, or close screen interposed between the dwelling-place and the wind currents will mitigate their malarial influence, and the inmate will be subjected only to local exhalations.

"Emin Pasha informed me that he always took a mosquito-curtain with him, as he believed that it was an excellent protection against miasmatic exhalations of the night."

The relief that we feel when breathing the air within the forest, as compared with the irritation often experienced outside of the forest, is undoubtedly due both to the purity of the forest air, together with its higher relative humidity, in which respects the forest and the ocean air resemble each other.

A remarkable collection of facts, relative to malarial fevers, is given by Dr. H. M. Clark, of Amritsar, India, in the last number of the *Scottish Geographical Magazine* (Vol. IX, p. 281). Dr. Clark's experience in India justifies him in stating that the planting of trees is a measure of special hygienic importance. Belts of trees judi-

ciously planted are of the greatest service; not only do they screen and shade the soil, thereby keeping it cool and preventing the development of the germs, but they intercept the poison and act mechanically as preventive agents. The tall, stately forest trees with dense foliage are undoubtedly the best; those having thin crowns are unsuitable. The shade-bearing trees with dense crowns are those that effectually screen from malaria-laden winds, intercept the rainfall, and protect the earth from the sun. In this respect the Indian fig or banyan, the peepul, the mango, and especially the plantain or banana trees, are remarkably efficient. These general conclusions, especially applicable to India, may well apply also to the United States.

The forests, therefore, act to diminish malaria:

1. By shading the soil so that its coolness prevents the growth of malarial bacteria.

2. By diminishing the wind at the level of the soil and thus preventing the spread of bacteria.

3. By sifting the wind through their leaves the trees catch the germs or delay their progress and give them time to settle to the ground, thereby protecting localities to the leeward.

4. Facilitating the formation of fog at night-time, by which the germs are carried down to the ground and the air purified.

From a hygienic point of view reforestation promises to be of great importance to the nation. We may, by studying eastern countries, see at once what we shall come to if we omit or neglect this process. I suppose that the planting of a forest in a malarial region does really diminish the tendency to disease, as has been so often maintained, and, in accordance with what I have just said, I should explain this efficiency as due, not to drainage nor to the absorptive powers of the eucalyptus nor to the anti-malarial influence of the sunflower, but to the fact that the forest covering shades and cools the soil to such an extent that the cool earth is no longer capable of developing the injurious forms of protozoa and bacteria. A soil that is alternately warm and cold, dry and wet, as is the case in the open fields, presents the best conditions for the development and dissemination, by the winds, of these microscopic germs. Carried to great distances by the wind, they settle in the water that we drink, and the food that we eat; they are inhaled into the lungs; they alight on every open sore or cut; they slip into the eyes and into the ears; they besiege us from the time that we are born until they have brought us low in death. Panting for a breath of fresh

air and for respite from their influence, we take a long sea voyage, or we welcome the great areas of purer cold air that come down to us from the upper regions as cold waves, or we sniff the fresh air after a rain or snow storm has washed off the atmosphere, and say, "How delightful!" In many ways man shows his innate hatred of dusty air; he seeks for fresh air by a few days on the mountains and in the woods; he chooses his dwellings on the windward side of the city, and, if possible, among the trees; he pays higher prices for the woodland than for corresponding open fields; he plants wind-breaks between himself and the winds, or anti-malarial groves between himself and the marshes. By his acts, if not by his theories, he recognizes the principle that the forest is essential to health and happiness.

Man must till the ground; some portion of the forest area must be cleared and cultivated. The forest soil that was so useful as a holder of water, the trees that were so graceful for food and foliage, the forest that was so beautiful to the æsthetic man, the playground that was frequented for recreation, must be demolished; but at what a fearful sacrifice, when we thereby stimulate the development of injurious bacteria and rob ourselves of pure rain and water.

A soil once cleared, drained, and cultivated may, after a while, become innocuous, but experience shows that in less than a hundred years after the removal of a forest the fertility of the soil has greatly diminished; the rains have washed away three-fourths of its nitrogenous ingredients; the hot sun has dried up and the storm winds have carried away another portion; the crop that is cut by the farmer has robbed the land of its small portion, and the land has become barren unless the most energetic artificial methods have been used to replace this loss. From this time forth the one simple and natural remedy is to return that land to its forested condition as rapidly as possible. *Af*forestation is an absolutely necessary sequel to *de*forestation. There must be a rotation of these two conditions, century in and century out, just as systematically as in the annual rotation of the ordinary grain crops. Every acre that is not needed for agriculture must be immediately planted and converted into forests if we would manage our territory on the most economical and rational system.

RELATION OF FOREST COVER TO WATER-FLOW.

By M. C. Read, Hudson, Ohio.

[Read at World's Fair Congress, October, 1893.]

The peculiarities of climate and the amount of rainfall are the important factors in determining the character of forest growth. To what extent the forests react upon the climate and modify its character is in most respects a disputed question. In this country it is not yet determined whether the extensive destruction of the forests has affected the amount of rainfall, but a very slight observation suffices to show that it has had a very important influence on the disposition of the rain-water after it has fallen. This influence can be learned as readily from the study of the character of the forest cover as it can from the visible effects of its removal.

A typical forest is not a mere aggregation of timber trees, and such wooded areas have only a moderate influence upon the disposition of rainfall. The dense undergrowth of shrubs, vines, and herbaceous plants are of prime importance, as well for the good of the forests as for its climatic influence. I have, in several instances, known of farm-forest reservoirs being completely destroyed by cutting out this undergrowth, regarded as useless, for the purpose of promoting the growth of the valuable timber, and securing the growth of grasses, so as to enlarge the pasturing area of the farm.

The forest areas of the northern and eastern States of the Union were generally of this typical character. In the swamps there was an almost impenetrable undergrowth of shrubs and herbaceous plants, and beneath them often a thick carpet of sphagnous moss. The uplands and hills carried a thick growth of large timber with a tangle of shrubs and vines and a smaller growth of herbs beneath, while the mountains were covered with a dense growth of smaller trees and shrubs pushing their roots into all the crevices of the rocks, which were too thinly covered with soil for the support of trees, but were generally covered with mosses, in which the roots of small shrubs and herbs found a foothold.

In all these areas the falling leaves were retained in the places where they fell, constituting a thick mulch, and by their gradual decay adding an annual increment to the soil.

Under such conditions, except when the ground was frozen, the heaviest rainfall would not cause a flood. The larger part of the water was retained in the place where it fell until it sank into the soil beneath, descending until it reached an impenetrable rock or clay stratum, along which it flowed until it found an outlet in various springs at a lower level. These springs were mainly the sources of the small streams, which, uniting into larger ones, found their way into the swamps, where their onward flow was checked, where they were spread out over the large surface of the swamps and the lakes and ponds usually connected with them, giving time for a large part of the water to sink into the strata below. The drainage was largely subterranean. The mass of the water in the streams was derived from springs from successively lower and lower elevations, keeping the flow nearly uniform and the water practically clear and limpid, as there was substantially no erosion or wash of the surface soil even in the hilly and mountainous regions. The streams were fed with filtered water. This has now all been changed; much of the change has been necessary and inevitable; some of it unnecessary and improvident.

The first work in the interest of agriculture was the destruction of forests. This was generally commenced on the dry land with a gentle surface drainage, and accomplished by cutting and burning the underbrush and timber, or on oak land by cutting and burning the undergrowth, and girdling the oaks, leaving them to die and gradually go to decay. These modes were not as wasteful as would now seem, as there was no market for lumber, and there was a marked advantage in returning to the soil as much as possible of the forest growth. On this kind of land the removal of the timber had at first but a slight influence on the surface drainage. The large amount of vegetable matter made the soil porous and absorbent, so that it received and retained most of the rainfall. As the roots decayed they left a net-work of subterranean channels which carried the water down to the subsoil and away beneath the surface. After years of cultivation these cavities became obliterated, the soil compacted, and the farmers were surprised to see land, formerly free from surface water, now so wet as to be almost valueless for tillage. In this condition the water was retained upon the surface until the depressions were filled and then largely flowed off into the neighboring streams, commencing that erosion of the soil which has given a muddy character to the water. The only remedy is through underdrainage, by which the capacity of

the soil to absorb and retain the rainfall is greatly increased. Gradually the deforesting was carried to the hills and the slopes of mountains, where the evil results were still more apparent. Deprived of the forest cover, these slopes carried off the water as from the roof of a building, which eroded the surface, washing away the soil, in places, to such a depth as to render the land worthless and make reforesting impossible.

After this the swamps and the lakes connected with them, the natural regulators of the streams, were attacked; the swamps were cleared and ditched; the outlets of the lakes deepened and straightened, until surface drainage was rendered as complete as possible. The results are everywhere apparent.

I write particularly in regard to Ohio, with which I am best acquainted, but extensive observations in other States indicate the same results. A multitude of springs which were once permanent have disappeared; others are intermittent and go dry in a drought. Very many wells have been deepened to secure a constant supply of water; streams once perennial are now alternately flooded and dry; those once flowing with clear pure water are now, during all or most of the year, muddy. One steaming down the muddy Ohio wonders why the early French explorers called it the beautiful river; but Mr. Samuel S. Forman, in describing a trip on a flatboat down the Ohio and Mississippi in 1789, describes the water as "clear and limpid," in graphic contrast with that of the Mississippi. At that time one of these streams drained a region almost entirely covered with virgin forests; the other mainly a treeless region; in one, erosion was at a minimum; in the other, at a maximum.

This carrying away of the rainfall by surface drainage instead of its being filtered through the soil has another very deleterious influence, the consequences of which can hardly be overrated. It robs the soil to a very great extent of its elements of fertility and dumps them into the ocean.

A full remedy for all of these evils is not easily found; they may partly be obtained by reforesting the poorer lands among the hills and mountains, at the heads of the streams, and maintaining them permanently as forest reserves. This reforesting can in most cases be secured through natural agencies. If the remaining forests are secured from the intrusion of domestic animals, and forest fires prevented, nature will soon clothe large areas, now nearly naked, with new forests.

In northern Pennsylvania are many thousands of acres which the

lumbermen have stripped of valuable timber and abandoned; much of this has been or will be forfeited to the State for unpaid taxes; much could be bought for a very small price.

In many places where the pine and hemlock have been removed a dense growth of black cherry has taken its place. In all places a new growth spontaneously appears which only needs protection to grow into a new forest. If all these lands were owned and controlled by the State, and made permanent forests, an important step would be taken in remedial measures.

Another step would be the thorough and systematic underdrainage of all ordinary farming land. It has been claimed that this increases the flow of water from the land, but this is certainly a mistake. While it prevents the saturation of the surface, it greatly increases the capacity of the soil to absorb and retain the water, and regulates and retards its overflow. After heavy rains the outflow from the exits of the drains is not immediately resumed, and this outflow is continued long after the surface flow has ceased. The outflow from the drains is clear and limpid, having the character of spring water, and carrying away none of the fertilizing elements of the soil. Both in wet and dry seasons the productive character of the soil is much improved.

In the distant future, and before the evil days prophesied by Malthus are upon us, the surplus rainfall will be largely retained in reservoirs and in cisterns connected with the draining tile, and used for irrigation during periods of drouth. The equivalent of a cistern $6 \times 6 \times 8$ feet for each square rod would have a capacity equal to one-third of the annual rainfall, on an average, in the whole region east of the Mississippi. Such cisterns could now be profitably constructed on small farms devoted to truck-farming.

If most of the reclaimed swamps were reforested, the gain to the public would be large. Along the divide in Ohio, which separates the waters falling into the Ohio and the lake, are many such swamps, which were formerly lakes, and are now generally connected with a chain of lakes and ponds. Under the present system these lakes are gradually filling up and will ultimately disappear, and these natural regulators of the streams be entirely destroyed.

These reclaimed swamps are so valuable for agricultural purposes that they will be long and perhaps permanently retained for this use. The abandonment of the culture of our most productive lands cannot be easily secured; such abandonment can be secured only by the substitution of some more profitable use. If these

lakes were needed as reservoirs for canals, the abandonment of the cultivation of the so-claimed swamps would be compelled.

If the experiment was tried of erecting dams at the outlet of any of these lakes, so enlarging them as to cover the adjacent swamps, devoting the enlarged lakes to the artificial culture of fish, and this experiment was found successful and profitable, the experiment would be repeated and all these lakes and swamps would be ultimately redevoted to their natural uses.

To secure any of these conservative measures the aid of the Government is almost if not quite indispensable. To secure this aid appeal must be made to one of the most important functions of government, which is now scarcely recognized, anywhere, by the government or the people. It is to require every one to recognize and obey the admitted maxim of the law "so to use his own as not to injure others," and including in the word "others" all who are to come after him; to recognize the fact that the present generation are only the life-tenants of a magnificent heritage, which they are required to leave to their descendants with its productiveness unimpaired. Whenever the present use seriously threatens future productiveness it is the duty of government to interfere and prevent waste by the life-tenants. The theory of *laissez faire*, every one for himself and his sable majesty take the hindmost, is one of the doctrines of devils that ought to be quite obsolete. We should be required to leave at least as much to our posterity as we have received by inheritance, and government should compel the present life-tenants to do this. If the undue destruction of forests tends to interfere with the future value of the state, government should interfere to prevent it. If reforesting is in any places required to secure future productiveness, government should in some way secure it. If to this end the preservation of the forests anywhere is required, government should *compel* their preservation.

FORESTRY MATTERS IN NEW YORK.

By Wm. F. Fox, Superintendent of State Forests.

[Read at World's Fair Congress, Oct., 1893.]

Conditions.

Although New York is the most populous State in the Union, one-fifth of its area is still covered with woodlands of original growth; namely, of its 31,468,800 acres, over 6,000,000 are forest land.

These woodlands are not distributed throughout the State, but, a few small areas excepted, are massed solidly in two large tracts. The greater one of these, containing about three-fourths of the whole, is situated in northeastern New York, and contains the far-famed Adirondack wilderness; the other and smaller one is situated in the southeastern part of the State, and is known as the Catskill forest, this latter tract extending, strange as it may seem, to within an hour's ride of the metropolis itself. There are no other extensive forests except the scattered patches or belts of woodland which may be seen in any of the agricultural districts of the Atlantic States.

A large part of these forests, both in the Catskills and Adirondacks, have undergone a material change through the operations of the lumbermen. Though densely shaded and heavily timbered, the experienced observer notes that certain species are missing. Seventy-five years ago these woods contained a magnificent growth of white pine, which in clearness, soundness, and quality of timber was unsurpassed; but it was removed so completely that comparatively few traces of this species remain. Here and there clumps of tall pines may still be seen, but on examination they prove to be ring-rotten, or otherwise worthless, and were probably left by the axemen for that reason.' Timber lots with good pine on them are now very scarce. At that time the lumbermen took the white pine only, spruce and hemlock having no value then. But the pine was cut so long ago that few traces are left of that period of lumbering; and now it is customary to call a spruce forest a primeval one, although a careful examination will show that perhaps fifty years ago the axemen went over this same ground in their quest for white pine.

So, to-day, the term "original or virgin forest" means, in the Adirondacks, a tract on which the spruce and hemlock have not been cut. The hard woods, owing to the fact that they cannot be floated down the streams, have been allowed to remain.

The merchantable species of the New York forests, in the order of their value, and quantity also, are, of the soft woods or conifers, black spruce, hemlock, balsam, tamarack, and white cedar, the thinning out of the forests and destruction in some cases depending on the presence and accessibility of these kinds. These conifers are mixed in varying proportions with the hard woods, but, for the reason already stated, the latter are not cut, except along the border of the forest, where they are easily accessible and can be hauled in-

stead of floated. The dominant species of hard woods in order of quantity are maple, birch, beech, ash, elm, and cherry, and in the Catskill forest there is considerable oak. Throughout the State, however, there are eighty-six species, not including tall shrubs.

The one merchantable tree mostly in demand by the lumbermen, and consequently the one most closely connected with forest conditions, is the black spruce. Its market value is less than white pine, but more than hemlock. Fully one-half the Adirondack forest has been cut over by the lumbermen in obtaining this species; at the same time, they cut the hemlock and the balsam as they go. These operations do not necessarily imply denudation, for the hard wood trees and some of the conifers are left; but the careless, improvident methods hitherto in use have, in too many instances, left the woods, where thus operated on, in a deplorable condition. In some places the mass of tree-tops, limbs, and brush have furnished material for furious fires, while in others the thinning out has been so great that the sun, wind, or rain has completed the work of destruction.

Until a few years ago the lumbermen, when cutting spruce, contented themselves with taking only the larger trees; but with a growing scarcity of timber and increased demand they cut smaller and smaller, until eight-inch butts and six-inch tops formed a conspicuous proportion of every log drive. This was bad enough; but with the advent of the wood-pulp industry they found a ready market for four-inch timber, and cut accordingly. In this destruction of young spruces the State is confronted with a most serious condition.

In the forestry outlook for New York it has always been considered a happy condition that its forests contained so large a proportion of spruce, a tree so well adapted to reproducing itself; that, while other States in their forestry management would have to deal with hemlock and pine, both of which will each reproduce only under the most favorable conditions, New York possessed a merchantable species which, with ordinary care and little expense, would furnish a perpetual timber supply. Some of the timber tracts in the Adirondacks, with no forethought or care whatever on the part of their owners, have yielded a second and even a third crop of spruce. But with the unrestricted cutting of spruce saplings and young trees for pulp-wood, now prevalent on most all the private timber lands outside the preserves owned by the clubs, a most serious condition confronts every one interested in the forests of New York.

At one time it was a matter of congratulation that the lumbermen left the balsam (*abies balsamea*), deeming it unmarketable. Its symmetrical spires beautified the forest, while its healing odors gave new life to stricken invalids. But of late years it has been cut with the spruce, the lumber when sawed, though inferior, being hardly distinguishable. The white cedar, a tree also valuable for its terebinthine odors, is being cut with the others, being used for shingles and fence-posts. The hemlock, valuable on account of its bark rather than its timber, is being cut to a great extent wherever it is accessible. Unlike the spruce, this tree does not easily reproduce itself, observation showing that the nurselings seldom reach maturity in that region. The tamarack has suffered so extensively from a wide-spread blight that but little merchantable timber of this species is left standing. Still, a large number of young tamaracks are cut in some localities for hop-poles, and where the larger trees have not died many of them are cut for square timber or sawed into dimension stuff. In short, there is a demand for each kind of soft wood, and each kind is being cut.

But little hard wood, comparatively, has been removed. On the borders of the Adirondack forest about 10,000,000 feet is being sawed annually, the logs being hauled to the mills. A large amount of hard wood is also cut in the Catskill forests for the furniture trade, the manufacture of wood-acid, and various other purposes.

In 1890 the mills along the edge of the Adirondack forest sawed 325,690,634 feet, of which 210,270,932 feet was spruce and 94,145,695 was hemlock. The pulp-mills in 1892 consumed over 100,000,000 feet of timber, all spruce, and mostly small young trees at that. It is evident that, unless this consumption can be checked or regulated, the timber supply of New York will be exhausted in twenty-five years.

Another important condition exists in the continued encroachment through petty agricultural operations. The lands thus cleared might far better be left under forest cover. The soil is worthless for any other crop, and it would be a charitable work to prevent the misguided efforts in this direction. The lands thus cleared never repay the patient toil laid out upon them. But the objectionable feature of these operations is not so much the loss of wooded area as the forest fires which are apt to ensue from the fallow burnings started to clear the land. Fully 450,000 acres of valuable forest have been destroyed in this State within thirty years from this cause alone. One cheering feature of the present outlook is that

this prolific source of destruction has been substantially eliminated. At least, there has been but little loss of area from this cause during the last six years. As to how far this is due to fortunate circumstances, or to well-directed efforts on the part of the State Forestry Bureau, it would be difficult at present to say. Much of the credit is certainly due to the latter.

The Catskill forests are an unbroken tract of about 2,100,000 acres, situated on the mountain ranges from which they derive their name. They differ somewhat from the Adirondack forest in this, that the hard woods predominate to a much greater extent. The white pine disappeared from the Catskills fifty years ago. Then the great tanneries which located in that region made a demand for bark that cut out most of the hemlock. The spruce went for building purposes. There is some hemlock and spruce left, but of an inferior quality. It is substantially a hard-wood forest, but with a greater variety of species than the Adirondack land.

Another condition, and a peculiar one, is due to the railroads which traverse both forests, and which are responsible for many forest fires, started by sparks from their locomotives. The Adirondack wilderness is penetrated by four different roads, and in the last year a fifth one was completed which runs through the entire forest, north and south. Along the roads previously built the locomotives have started fires which have not only cut a wide swath along the whole line, but have eaten their way, in some places, a long distance laterally. The road last completed is carefully watched in this respect, as it is controlled by parties who own immense tracts of timber land immediately adjoining its line. Still, if it does not inflict serious injury on the woods along its route, it will be the first one that has not. The Catskill forest is also intersected with railways, and the annual reports from the fire wardens in that region teem with complaints of fires started by sparks from locomotives. While it is conceded that railroads are a valuable adjunct in marketing forest products, it is doubtful whether they are a benefit to a communal or State forest unless operated under the forest government and for forestry purposes mainly.

In discussing here the more important conditions, mention may be properly made of the State government in its relation to forestry matters. The State owns 677,220 acres in the Adirondacks and 48,491 acres in the Catskills—a total of 725,711 acres, which have been set apart by law as a forest preserve. These lands, for the most part, reverted to the State through the non-payment of taxes,

a very small proportion having been obtained through purchase. Eight years ago the care and management of these lands was vested in a State bureau styled the Forest Commission, an honorary board of five members, selected with reference to well-known integrity and ability, who serve without pay. Under them there is a superintendent of forests, with the necessary corps of assistants, inspectors, and foresters. Hitherto the administration of the Commission has necessarily been confined to a police management, looking merely to the protection of the State forests from fire and timber thieves. Owing to the scattered condition of the State holdings and insecurity of title, no definite system of improved forestry could be prudently undertaken.

Mention should be made, in this connection, of the numerous clubs which own large tracts of woodland within the line of the Adirondack Park, these corporations, large and small, owning about 550,000 acres. This condition is a highly favorable one, as the existence of the clubs, their aims and purposes, are dependent on the preservation of the forests which cover their lands. Three of these clubs, or associations, own over 100,000 acres each, or a total of about 390,000, all fine timber land, containing more than the usual proportion of merchantable species. While holding these as game preserves and summer resorts, they sell timber rights in some instances, but under restrictions which prevent any serious injury, the restrictions specifying the species and size of timber that may be removed.

Problems.

After years of careful study of the situation, made on the ground itself, the conclusion is forced that there are two things for the State to do. It must acquire substantially the entire territory within the boundaries of the Adirondack Park, and then inaugurate an intelligent system of forestry based solely on the question of a future and perpetual timber supply. All other matters are subordinate, and any discussion of them is merely time lost. If the State will push steadily along on these two lines, the other questions will solve themselves without further care.

But why purchase the entire territory? it may be asked. Because the preservation and future existence of that forest in its entirety is dependent on communal instead of private interests. The former is unchangeable in its character; the latter is not. A communal interest is based on perpetuity of title and on a management looking to the future rather than the present. A private

interest means successive changes in the title, and a management based on present needs.

There are large tracts, held by clubs or individuals, whose management indicates that their forests will be preserved during the present ownership. But it is only a question of time when these lands will pass into other hands and be managed with reference to pecuniary needs.

Now, if the State acquires the territory, its management, however lax or open to criticism, will never fail through stress of such a motive. State ownership will insure forest preservation, even it fails to secure an improved forest and an increased product. Private ownership cannot insure forest preservation, because of its changing tenure.

The 677,000 acres of State lands within the Adirondack Park were acquired through tax sales, and consequently are scattered so widely throughout the private holdings that no improved system of forestry can be attempted. The remaining forests through which these lands are interspersed should be bought, or else the whole forestry project should be abandoned. The movement should be forward, not backward. Which shall it be? To merely stand still; to be contented with holding the lands now owned, and paying taxes on them, as the State is now obliged to do; to maintain an expensive bureau while progress is impossible, is worse than idleness—it is retrogression.

The State must buy more land to consolidate its present holdings, which are scattered over the map like the squares on a checker-board. In providing means to purchase additional lands, a sufficient amount should be appropriated to complete the purchase of the entire forest within the limits of the Adirondack Park. While the press, people, and State government favor the acquisition of these forests with a remarkable unanimity, time has been lost by looking toward futile and evasive measures instead of boldly approaching the matter in the one, the right, and the only way—by purchase. Some friends have looked for further acquisitions through tax sales; but the agitation of the forestry question has enhanced the value of woodlands in New York until there is no more reversion of land through defaulted taxes. Some have depended on controlling improvident timber-cutting by offering exemption from taxes, a law having been passed to that effect; but the land-owners reject the offer of tax exemption, preferring to cut their timber as close as they please.

There remains only one thing for the State to do: if it wants that land, it must do as individuals do when they want land—the State must buy it.

And there should be no hesitation about buying it. A State that can afford to put $20,000,000 into one building can afford to vote one-fourth that amount to preserve its forests. Money paid for these forests is not an expenditure; it becomes a first-class investment. The lands can be sold at any time for cost, and in the meanwhile they will produce a revenue more than sufficient to pay the interest on the bonds issued for their purchase.

Many advocate the condemnation of these lands; but condemned lands must be paid for, and the money must be appropriated by the legislature the same as for purchases. To seize land by right of eminent domain is a harsh and unpopular measure that should be held only as a last resort. Moreover, the bulk of the land can be bought, through the ordinary methods of bargain and sale, at prices less than the land would bring under appraisal. Appraisers always give the benefit of a doubt, and justly so, to the man whose land is condemned.

A large fund for the purchase of land will soon be available through the operation of the law of 1892, which authorizes the sale of scattered, outlying tracts, situated so far from the main forest that they cannot be used in connection with any well-defined plan of operations. This law directs that such sales shall constitute a fund which may be used only in the purchase of lands situated within the Park boundaries. These outlying tracts, owing to their accessibility, bring high prices, which enables the Commission to not only locate their land to better advantage, but to increase the acreage.

After the outside lands have been sold and the proceeds invested within the Park lines, the area yet to be purchased can be definitely ascertained. The legislature will then be asked to authorize an issue of bonds to be used in purchasing the remaining area.

This, then, is the one great problem to-day—the further acquisition of land. Fortunately, the attitude of the State government is a favorable one, and the legislature grants annually an ample appropriation for the maintenance of the Forestry Department and its work. The Governor of the State, Hon. Roswell P. Flower, is deeply interested in the forestry movement, and fully appreciates its importance. He supplements his study of the various questions with a personal inspection of the forests and extended trips through the

wilderness in search of information bearing on the various matters connected with the subject. He gave his personal attention to the forestry bill passed last winter, and originated some of the more important amendments. His sturdy and valuable support is the most cheering feature of the outlook.

But the legislature, in considering the propositions looking to an appropriation or issue of bonds, evince a conservatism bordering on timidity, and are evidently reluctant about passing any bill which might raise the tax-rate in any noticeable degree. And it is right here, around this point of the tax-rate, that the whole matter revolves.

It may be, however, that with the funds accruing from the sale of outlying lands and from the sales of matured spruce the Bureau may be able to make purchases which will consolidate their present scattered holdings and give them about 1,000,000 acres of forest, which, though it may not be in one solid tract, will be favorably located and furnish an opportunity for inaugurating a better era in forest management.

There are other problems which have occasioned considerable discussion and study; but they are technical ones, and a rehearsal of them here might not be timely, for lack of space. They involve the questions of thinning, reforesting, and protection of denuded hillsides.

Throughout the State preserve there are some tracts which have been burned over, and which are covered with the aspens * and bird cherries † which, in the Adirondacks, invariably follow a fire. These aspens, or poplars, are fast growers, becoming available for pulp-timber in a few years, and should be sold then, as they are a very short-lived tree. Problem: how to thin out so as to get the greatest yield, and, at the same time, promote the advent of the spruce and other conifers, which always appear before the poplars die off.

Again, there are areas which have been burned over repeatedly, until even the poplars fail to appear. Problem: what species can be planted and grown successfully under such unfavorable conditions?

Again, there are mountain slopes denuded by fire or cyclones. Problem: how shall the charred and fallen tree-trunks be best arranged so as to prevent the loose soil from being washed away,

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* *Populus tremuloides.* † *Prunus Pennsylvanica.*

and hold it in place until nature can do the work of reforesting? There is a fine opportunity for an experiment in this line on the east slope of Whiteface; and as soon as the State purchases this land the experiment will be undertaken.

But a full statement of the conditions and problems connected with the New York forests would require a volume. Suffice it to say here that perplexing and confusing as those conditions and problems are, that despite errors, disappointments, and delay, forestry matters in New York are moving, and in the right direction. It will not be long before results will be attained worthy of that great State, and satisfactory, it is hoped, to the American Forestry Association, to whose untiring efforts in arousing public sentiment the forestry movement in New York owes its inception and existence.

THE FORESTRY PROBLEM IN PENNSYLVANIA.

By J. T. Rothrock, State Forestry Commissioner.

[Read at World's Fair Congress, Oct., 1893.]

The State of Pennsylvania, long one of the most important lumbering Commonwealths of the Atlantic seaboard, may be said to have passed the zenith of its prosperity in this particular interest. It is true that it still produces considerable white-pine lumber each year, but it is also true that the increased quantity of hemlock cut, as compared with white pine, shows clearly to those familiar with the facts of the case that the original growth of the latter is almost gone. Over a large portion of what was once the seat of extensive operations in both white pine and hemlock the chief—indeed almost the only—lumbering trade now is in jack and yellow pine, so called by the Pennsylvania woodsman. These smaller trees are, year after year, being taken to meet the increasing demand for mine props. Tram roads are extending constantly into regions which have hitherto been inaccessible, and now branch railroads are placing a premium upon the removal of timber which up to this time could not be removed at a profit to the owner.

Much the same may be said of the various hard woods. It is probably correct to say that if any kind of timber is being reproduced within the limits of the State of Pennsylvania as fast as it is removed, it is chestnut, and that alone.

That this should be the case is unfortunate, but it was unavoid-

able, because, first, the timber cut has been expended in legitimate trade, or it was removed to make room for farms before the present railroad facilities for travel invited the home-seeker to more productive agricultural regions in the remoter west.

Accepting the facts, the important question is: What is the remedy?

This question is too broad to answer fully here. It is safe to say, as a necessary preliminary, that each family must in future be content with less land for farming purposes, and that the lesser area must produce better crops under better cultivation, and that economy, and not extravagance, must dictate the quantity of wood used hereafter.

Under any conditions, however, a large portion (area yet undetermined) of the State can never be used to advantage for any other purpose than the growth of timber—agriculture being wholly out of the question. On such parts the care and culture of timber must be insured by one of two methods, *i. e.*, State ownership, or by making it profitable to individual or corporate enterprise.

Whilst it is true that a certain portion of these lands will almost inevitably pass under the control of the State, it is equally certain that the larger portion is likely to remain as private property. Hence any solution of the problem must be broad enough to meet both State and private ownership.

At the outset, let it be said that the tendency to reproduction of timber of all the native kinds by natural methods is very strong in Pennsylvania. The thrifty groves of young white pine, for example, show this most clearly, for it, of all our trees, was regarded as the one whose continued preservation was in greatest jeopardy.

The one greatest foe to this reproductive tendency is the unchecked forest fire, whether the land is owned by the State or by the individual. Hence it goes without saying, that a remedy here is of the first importance. It is not physically impossible to check it, though it may be for a certain time, until public opinion is more matured, impossible to obtain the most effective legislative aid. Money and legal enactments combined would do it if both could be obtained to the desired extent. But to press at once for either or both of these on the basis of the greatest efficiency would be to arouse hostility, which would long postpone the desired end. There must be a wise conservatism, which will carry conviction before each increasing demand. What may be done in a moderate, practicable way?

1st. Woodlands are often fired to destroy underbrush in order to furnish pasturage or better browsing for cattle. This part of the problem could be easily met by the confiscation of all cattle found on other woodlands than those of the owner, unless they were there by his permission.

2d. Woodlands are often fired, maliciously, to injure the owner, or (which is hardly less criminal) to clear underbrush, and thus lead to production of a larger crop of berries. In such cases there seems to be no remedy short of the appointment of special State officers, whose business shall be to ferret out the offender, by individual search, or by this combined with a liberal system of rewards leading to the detection of the criminals, and by punishment of the guilty parties, by the State. It is hardly safe to leave this to a local tribunal, and, as the benefits of the forest extend to the State at large, the State, which suffers, should hold the power of punishment.

In this connection it may be said that the plan of calling out aid to suppress fires, and then paying the laborers, has been fairly tried in portions of the State, and that the results have not been satisfactory. Whilst one party was engaged in extinguishing fires, others were engaged in starting them. The compensation clause, in other words, has led to producing fires as a means of obtaining work. It would, however, be premature to say that there is no legal remedy for this condition of affairs, but that the difficulty is at present a serious one is beyond dispute.

3d. Among the causes of forest fires in Pennsylvania, railroads must be counted as most active, as, indeed, they are everywhere. Where the fire can be clearly traced to a passing train, there is, of course, a legal compensation. But to fix the fact is seldom easy, and the sufferer who seeks the assistance of the law is frequently, if not usually, beaten in the contest. Two remedies appear: one is to compel the railroad companies to employ a sufficient fire guard to protect the forest lands through which their lines pass. This might lead to greater care in furnishing locomotives with efficient spark arresters or consumers. The other remedy would be to compel the companies to purchase land for, say, a rod on either side of the road-bed in wooded areas, and to keep it clear of combustible material. Whether either of these remedies would prove practicable at present would depend on the relation of the railroads to the legislature, and here somewhat uncertain elements are introduced.

4th. Debris left after lumbering operations is a most prolific

cause of fires of the most damaging character. It is well known that when this has been consumed subsequent fires are less destructive, because so intense a heat is no longer possible. It is then in order to indicate that those who create this debris should remove or destroy it by some safe method. But the remedy so proposed would meet, it is clear, as yet with so sturdy an opposition that it is probably impracticable. So, too, the maintenance of "fire lanes" through our timbered areas would involve a cost for which our legislators are not as yet prepared.

Hence it is of the utmost importance that agitation of the forestry problem should yet be continued, to mature public sentiment in the proper direction.

The second most serious factor in the forestry problem is the tax upon timber land. There can be no doubt but that the sentiment in favor of total abolition of tax on all standing timber is maturing very fast in our State. There are, however, two difficulties in the way. First, the constitutional clause which demands equal or proportionate taxes on all property within a certain class. This might be obviated by making forest lands a class alone.

Then, again, a second difficulty arises when we remember that certain sparsely populated counties derive their tax income in great part from forest lands. To remove this tax would be to such counties a serious loss, if it did not, indeed, actually hinder their proper development. Take, for example, the maintenance of proper roads, which now depends largely upon this very tax. There is, of course, this to be said, that the day is probably not far distant when these roads will become the care of the State instead of the township.

The tax aspect of the problem merits a more extended consideration. It can be shown that there are extensive woodland areas in Pennsylvania on which in the past thirty years more tax has been paid than the lands could be sold for to-day, and that during this entire term of years the lands have been wholly unremunerative to the owners. It is clear that such lands have been practically confiscated by existing laws. Can we wonder that under such circumstances the owner should be driven to remove immature timber in order to realize what he could, and then, often, to allow the lands to be sold for a nominal sum to meet the taxes? To be sure, this may, in some instances, be the gain of the State; but more frequently it is just the reverse. Let us imagine for a moment that the taxes had been removed. The owners would realize that here,

in their timber, they had a property which was growing into value, however small, without actual outlay to them. Neighbor would join with neighbor to protect it against the only serious foe—fire. To guard it would become a concern of the community; the incendiary would speedily find himself placed in a light in which he had never stood before. To fire a forest would become a thing of as bad repute as to steal a horse, and protective associations would be formed to guard against the former, such as already exist to guard against the latter. The writer is not drawing upon his imagination in this aspect of the problem, for he has good reason to know that such associations are already being considered by those who are most deeply interested.

Let us consider the tax question from another standpoint—that of equity. We are told the forests are growing into value, and that the owner will hold them with this object in view. Grant the full force of this statement; is it not true that every day a forest stands it is earning its living in the good it is doing the Commonwealth by retarding freshets and hoarding water? Or even admit in its baldest form the truth of the statement that they are growing into value for the owner. Is it not equally true that this is the most desirable thing possible for the Commonwealth as well? Has it not become, in certain parts of the world, a maxim of political economy, that the forests are as necessary to the State as to the individual? Take our larger cities! Whence comes the best water which supplies them but from the higher, timber-clad slopes of distant regions. This indispensable element, this hourly necessity, they pay actually nothing for the production of until it reaches their own suburbs. A readjustment of taxes might make it possible for these cities to furnish under State distribution the means by which sparsely populated counties could be developed, even if the tax had been taken from their timber lands.

It has been suggested by some thoughtful persons that, instead of removing the tax from timber lands as a whole, it would be well to retain it *on all unseated timber lands*, but to set apart that tax for the specific purpose of employing wardens and workmen whose duty it should be to protect these lands from fires. There is much in the idea to commend it to a most careful consideration. The chief obstacle seems here, again, to be the constitutional one of discriminating taxes within the same class of property.

There can be in this country no genuine, practical forestry developed until the owner is made to realize that in his trees he has a

paying crop. When this idea has taken possession of him, all the rest will follow. If he fails then to discover methods by which this crop may be produced in largest measure and in the least time, it will be the first instance in which he has been known to fail in that direction. It is time for us to realize that an analysis of the elements of the forestry problem will show we do not have everything to learn. That, indeed, in some phases of forestry, we are already well up, and it is barely possible that we could develop, for most of the remainder, methods of our own as speedily as we could adopt those from abroad. I trust I shall not be misunderstood in this allusion. No man honors more than I do the science of forestry as exhibited in Europe, but I also insist that it is full time for us to assert the individuality associated with national life, law, and with a change of latitude. I am convinced that what we chiefly have to become proficient in is the mere planting and care of trees on a large scale. The engineering, the removal of trees, and the care of lumber are already well known. And be it observed that in these very points our foreign brethren are often greatly at variance with each other. With game laws and game preservation we are not concerned at present, and probably never will be. The relation of trees in producing fertility of soil, tempering climate, and to water supply are scientific problems of the greatest interest, but they are not factors in the practical restoration of forest resources. It is, however, greatly to be desired that special experts should be induced to lend their aid in placing these problems on a proper basis, and that we should contribute our share towards the world's stock of knowledge concerning them. But this, I repeat, is an aspect with which we are not necessarily practically concerned just now.

There are, however, certain aspects of the forestry question in which we are immediately and practically interested, and which relate specially to our own side of the Atlantic. I mean the rates of wood production, the time of wood maturity, and especially how both these, and the quality of the timber as well, are affected by soil and exposure. I am convinced these are problems which we must settle here for ourselves. And they bear directly upon the economic side of the subject. For example, it would be most important to determine by observation here what is the actual average yearly wood production per acre. It is quite clear that many whose opinion seems entitled to respect, and whose opportunities for observation have been large, place the figures higher than a trans-

atlantic forester would admit as probable. There are also certain ratios of increase for the individual tree at different periods of its life, which possibly may be tabulated, and which involve practical considerations of vast importance.

Among the trees which deserve the special attention of the Pennsylvania forester is the white pine. In so far from being a tree of difficult reproduction, and which, therefore, is tending to extinction, the exact reverse is the case. Over a large part of the area on which it once grew it is now growing luxuriantly and spontaneously. More than any other important tree of native growth, except the chestnut, it grows with an even rapidity. It would be safe to say that in from sixty to sixty-five years one may expect a tree whose diameter at two feet above the ground will be from eighteen to twenty-four inches. There are, of course, notable exceptions. Some trees, for example, whose history we know, have fully doubled this rate of growth; others have fallen proportionately as much below it.

A striking exception to the above statement is found in the fact that out of a large number of matured white pine trees growing side by side, and apparently of about the same age, some will reach a diameter of four feet across the stump, and others possibly not more than half as much. This was well shown in Centre county (Pennsylvania), where the age of the grove alluded to was about two hundred years. It should also be mentioned that the growing white pine of to-day is found, as that of the primeval forest was, in "patches." It is not evenly distributed, even on areas where it grows naturally. This very simple fact, clear to all observers, is of value chiefly to show that the altered environment has not in any way disturbed the natural method of reproduction, and that the essential element in the restoration of this tree is simply what it always has been—time.

The term "sap pine" as used in connection with the white pine has almost come to indicate that it is essentially different from the fine, soft, clean lumber of earlier days. This error, which is perpetuating itself, is mischievous, because it encourages the premature destruction of trees which are actually growing into the most desired condition of white pine.

After years of agitation, forestry legislation of a satisfactory character was obtained at the last session of the legislature. The bill as finally passed is here introduced. It will be observed that it aims at two things: first, to ascertain the real condition of our

forest resources, what the possibilities of the future are, and then with the preliminary data at hand to endeavor to inaugurate a positive comprehensive forest policy, or something as near to it as our legislature can be induced to grant.

No. 68.

AN ACT relative to a Forestry Commission and providing for the expenses thereof.

SECTION 1. *Be it enacted by the Senate and House of Representatives of the Commonwealth of Pennsylvania in General Assembly met, and it is hereby enacted by the authority of the same,* That the Governor be authorized to appoint two persons as a commission, one of whom is to be a competent engineer, one a botanist, practically acquainted with the forest trees of the Commonwealth, whose duty it shall be to examine and report upon the conditions of the slopes and summits of the important watersheds of the State, for the purpose of determining how far the presence or absence of the forest cover may be influential in producing high or low water stages in the various river-basins, and to report how much timber remains standing of such kinds as have special commercial value, how much there is of each kind, as well, also, as to indicate the part or parts of the State where each grows naturally, and what measures, if any, are being taken to secure a supply of timber for the future. It shall further be the duty of said commission to suggest such measures in this connection as have been found of practical service elsewhere in maintaining a proper timber supply, and to ascertain, as nearly as is practicable, what proportion of the State not now recognized as mineral land is unfit for remunerative agriculture and could with advantage be devoted to the growth of trees.

SECTION 2. The said commission shall also ascertain what wild lands, if any, now belong to the Commonwealth, their extent, character, and location, and report the same, together with a statement of what part or parts of such lands would be suitable for a State forest reserve, and further, should the lands belonging to the Commonwealth be insufficient for such purpose, then to ascertain and report what other suitable lands there may be within the State, their extent, character, and value. The final report of the said commission shall be presented to the legislature not later than March fifteenth, one thousand eight hundred and ninety-five.

SECTION 3. The said commission shall have power to appoint one competent person to act as statistician, whose duties shall be to compile the statistics collected by said commission under their direction and supervision, whose salary shall be one thousand dollars per annum, with necessary expenses to be paid in the same manner as is hereinafter provided for the payment of the Forestry Commission.

SECTION 4. The commissioners appointed hereunder shall be entitled to receive, by quarterly payments, a compensation as follows: The engineer, twenty-five hundred dollars ($2,500) per annum; the botanist, twenty-five hundred dollars ($2,500) per annum, with necessary expenses for each, and the sum of twenty thousand dollars ($20,000), or so much as is necessary, is hereby appro-

priated out of any money in the Treasury not otherwise appropriated to be paid by warrant drawn by the Auditor-General.

Approved, the 23d day of May, A. D. 1893.

ROBT. E. PATTISON.

The foregoing is a true and correct copy of the act of the general assembly, No. 68.

SECRETARY OF THE COMMONWEALTH.

FOREST CONDITIONS IN THE NORTHWESTERN LUMBER STATES.

By C. H. PUTNAM, Eau Claire, Wisconsin, Vice-President American Forestry Association.

[Read at World's Fair Congress, October, 1893.]

By the Northwestern Lumber States we mean the States of Michigan, Wisconsin, and Minnesota, bordering on the great lakes, which have been the base of supplies for pine and hard-wood lumber for the past forty or fifty years, and without which the vast and rapid settlement of the adjoining prairie States of Illinois, Southern Wisconsin, Iowa, Minnesota, and even Eastern Dakota, Kansas, and Nebraska, might have been almost impossible, or very much retarded; so that we may say those three forest States have made the development of the prairie States possible, and we may also add that the States named are interested, in a great measure, in the perpetuation of said forests, for they are still the base of timber supplies. Another important factor to the prairie States is that these same forests, if properly cared for and preserved, will be the guardian angels over floods and water supply on the Mississippi river and its thousand tributaries, to save the disasters of spring floods, hold back the snows, and thus secure an even and timely flow of water through the season.

The writer for the past thirty-seven years has travelled extensively in the States of Wisconsin and Minnesota, observing the forests, streams, and watersheds carefully, and can truthfully say that if the said forest States become disproportionately cleared and bare, allowing the heavy snow and rainfalls to run off rapidly in the early spring, cities and towns and farms along the lower river could not exist where they are now located. I do not think people have

given this subject much thought—the preservation of forests at the heads of our main rivers.

It is a subject, however, that can be very easily studied in some parts of Europe, and in our own country; on the Potomac especially, where one can see a water rise of 25 or 30 feet, when within the memory of old settlers it did not formerly exceed 10 feet. Along its course, while once the old homes were in the valley and near the river, they are now on the higher land and the hillsides; the forests along the river and at its head are largely destroyed, and the waters run off rapidly.

This digression is made, as it throws some light on the problems regarding the northwestern forests, and calls attention to the fact that a vast area outside of the forest areas themselves is directly interested in their permanency.

When the census of 1880 was taken, the timber in said States (forests) of economic value was estimated by the writer for the maps which were to show the forest areas. At that time the white pine (*Pinus strobus*) was reckoned as the most important timber and of the most value, and the principal inquiry was directed to that timber.

There was reported May, 1880, estimated upon the methods of logging then in vogue, some one hundred and twenty billion (120,000,000,000) feet of pine timber was standing and growing in said three States. Of this amount quite one-half has been cut.

Estimation was also made of the hemlock, cedar, etc., over the same area, but not so carefully as of the *then* more valuable timber—the pine—but enough to know that, considering the enhanced value, and added information regarding these other forest products, the forest remaining will be of more value than the white pine that has been removed. So that we have even now a vast and valuable forest remaining. The region, especially in Wisconsin and Minnesota, abounds in lakes and streams full of pure, soft water; the soil is mostly of the drift period—a sandy loam, interspersed with sandy and rocky areas, fit only for tree growth, the climate most favorable to the development of a large number of forest trees; altogether the conditions are such as to permit, at small expense and care, keeping the forest, wherever desirable, in good and ever improving condition.

When the lumbermen get through with the merchantable pine timber and move out, this great forest area can rest, recuperate, and grow, and re-establish some of its primeval conditions. There

is a vast amount of hemlock, cedar, linden, maple, oak, and other woods in this forest not found in the forests of the southern States, the rockies, or the Pacific coast, and this hard-wood timber forest of these three timber States must for all time be the base of supplies for the adjoining prairie States. Judging by the amount of white pine that is being cut each year from the three States (some eight or nine billion feet of lumber), and knowing that the white pine is but a small part or percentage of the timber making up the forest proper, we can form some idea of the vast extent and value of the same.

It is a notorious fact that the lumbermen who have had the run of this forest for the past forty years are not poor men. They have paid thousands—yes, millions—of men and women laborers good wages, and the laborers are not poor. A million farmers in their own and adjoining States have had the product from this forest, and they are not poor; even the game that we find is fat, and when we say that the best of the forest is still there it needs no further argument to establish its present and prospective value for its product alone, saying nothing of its protection to water and soil conditions and climatic sanitary value.

Now, what is best to be done for this valuable property to preserve it in ever-producing condition, to prevent its threatened depreciation by fire and improper methods of exploitation, and to secure the benefits that depend upon its preservation?

In the State of Wisconsin—my home—we have the northern half of the State yet in forest, and I will here say the cutting of the white pine does not *destroy* the forest, if properly and carefully done—does not change forest conditions very much; indeed, in some places it is a benefit to the small pines and deciduous growths.

Our State school fund has some half million acres in said forest set aside for schools, universities, etc. Last winter I recommended to our State officers that they withdraw from sale said tracts, and advocated the organization of a State forestry association which, in conjunction with the State officials, should act in its care and preservation, and also to seek to add to its area in various ways. For instance, the General Government has still unsold in Wisconsin a half million or more acres of land within its forest area. I advised to procure from the Government this area and to add it to the State lands. I would also advise lumbermen and land-owners who have forest lands, to turn over to the State such of their lands as they could spare, and thus have the State acquire and hold and care for

forest reserves. I may add a State Forestry Association was so organized in Wisconsin. From these reserves ripe timber could be sold at a profit and still the forest be kept intact. The writer has studied carefully in Europe the methods pursued in forest management at the head of the Elbe, and in Baden, and in other forests, which in the main are perfectly practicable in such a State forest reserve. I would also advise the same plan to be adopted in Michigan, Minnesota, and in fact any State that has forests. Such forest lands in the hands of the State would be free from taxation, but would yield an income from the sale of timber, and they would be, at the same time, a preserve for game and fish and a resort for our prairie neighbors.

I have travelled over the forest reserves of the state of Baden, east of the Rhine valley, and bordering on Switzerland, and in Southern Germany, and I know that the lands of Wisconsin, Michigan, and Minnesota, commonly called "Cut Pine Lands," and considered of but little value now, are quite as good as the "Black Forest" in general if cared for as that of Baden is. In the forests of that State, of about 235,000 acres, not larger than one of our big timber counties "up North," the management employs 92 men as foresters, and there is a good revenue above all expenses of nearly $3 per acre every year, and yet the timber growth is increasing.

I cannot close without alluding to the greatest bane to which the forests of these States are uselessly and ruthlessly and unnecessarily subjected every year. The losses of valuable forest and other property, and especially the destruction of favorable forest conditions for the future, which is due to the conflagrations during the last two months, show most drastically the need of State care and watchfulness over the same under competent men. The losses this season alone by fires in the forest could, in many instances, have been avoided and an amount saved that would have paid all expense in the care of forests for the next twenty five years. In this country so few people seem to realize the difficulty and cost of planting timber, and the consequent value of standing timber now to be found in the natural state.

Summing up the foregoing remarks upon the subject, "Forest Conditions of the Northwestern Lumbering States," we recommend that these States and all other States in the Union that own forest land—and most of them do—whether light or heavy, swamp, university, school, or other lands in a wild state, withdraw said lands from sale, except where needed for agricultural purposes,

and make of such lands a forest reserve, added to by donations from lumbermen, of their lands from which they have cut and removed the white pine, having received from this one item alone twenty times the first cost of the land, and who have no use for the remaining soil or timber and would be willing in many cases, for a small consideration, to convey titles to the State. To this might be added either by purchase at a nominal price, as indeed the low price of the "graduated" lands and that of the remaining unsold Government lands in each State will warrant. These lands should be placed all under the care of an intelligent forest commission in each State, who, acting with the State authorities, could estimate and sell the ripe timber, having the same properly cut and receiving for the same full value, instead of selling, as is done now, for a set price, without much regard to relative values, land and timber, which is unbusinesslike and ruinous.

FOREST CONDITIONS AND NEEDS IN THE SOUTHWESTERN TERRITORIES.

By Edward F. Hobart, Santa Fé, New Mexico.

[Read at World's Fair Congress, October, 1893.]

The Southwestern Territories, New Mexico and Arizona, contain about ten millions of acres of forest lands. The greater part of this is "pure" forest of yellow pine (*Pinus ponderosa*). Often, however, Douglas firs (*Pseudotsuga taxifolia*) cover the hill-sides that face the north, some of the species attaining a diameter of four or five feet. Occasionally, also, a vigorous growth of aspens (*Populus tremuloides*) occupies a large area, and smaller patches of oak (*Quercus undulata*) are found.

Along the streams are the two species of cottonwood (*Populus monilifera* and *Populus augustifolia*), the box-elder (*Acer negundo*) and other deciduous trees. In the southern part of the Territories the lower growth that accompanies the cottonwood in the valleys is mainly mesquite (*Prosopis juliflora*) and torneo (*Prosopis pubescens*). Also vast areas of rolling lands in different parts of the Territories are covered with a thick growth of pinon (*Pinus edulis*) and cedar (*Juniperus virginiana*).

The climate of New Mexico and Arizona is not favorable to the growth of young trees except in the depths of the undisturbed forest—unless, indeed, they are assisted by irrigation. But not more than one per cent. of the area now covered by forest can be irrigated. The average rainfall outside of the higher mountains does not exceed one inch per month. In the mountains it is double that amount. This small amount of precipitation renders it almost impossible that the forest if once destroyed shall grow again on land trampled by stock, as is the open unirrigated area of these Territories.

Here, then, we have a property immensely valuable—valuable for the excellent lumber that it furnishes for building and other purposes; valuable for the luxuriant pasturage in the forest glades; more than all, valuable for the protection that the mountain forests give to the sources of the water supply. Water for irrigation is the life-blood of the Territories. Upon it their growth and prosperity mainly depend. The precipitation in the mountains comes in great part in the form of snow. But the snow scarcely falls on the mountain peaks before the strong northwest winds that prevail in winter in those elevated regions hurry it off and it accumulates in the wooded valleys, often to the depth of fifty or more feet. There the giant spruces extend over it their protecting arms, and its melting is thereby so retarded that it feeds the streams the whole summer through. Also, when the rains of summer fall on the mountains they are in part absorbed by the forest cover, and that water is given out slowly to the springs, so that it all becomes available for the use of the irrigator. Where, on the other hand, the hillsides have been denuded of timber the water rushes off quickly, gullying the land and rendering it useless, and floods are produced which cause injury instead of benefit to the farms below.

Here, then, is a matter of most vital importance. The facts are plain. No one who knows the country can doubt them. The Government is directly interested as the owner of the greater part of the forest. The interests of all those living in that vast region also make an appeal, that cannot be justly disregarded, for Government aid, without which nothing can be done. One hundred million of dollars would not compensate for the loss that would result if those forests should be destroyed. And they are being destroyed with great rapidity. Too close cutting, too close pasturing, and forest fires are doing the work. What is needed is some means on the ground of guarding against these foes. The authorities at Wash-

ington, however anxious they may be to help us, are unable to do so effectually under the present system. Even in the case of a devastating fire last summer in the Pecos timber reservation of 300,000 acres, it took two or three weeks' time before I, who was then the proper officer of the Interior Department, could secure authority to extinguish it. I soon thereafter succeeded in putting the fire out, but not until one-fourth of the park had been burnt over. While such a fire does not kill the larger pines, it does destroy the young growth, and so almost ruins the prospects for future years of the section it covers, and it burns up the great spruces, root and branch. During the first rains after this fire the streams rising in the park ran black as ink for days from the forest cover that was destroyed by the fire and which was then washed away, leaving the ground bare and desolate.

Now, if the Government cannot be brought to care for all its forests in a businesslike way, a beginning should at least be made with these timber reservations.

Let us urge that some legislation in regard to them, similar to the Paddock bill, be enacted at once, and then we may hope that the good that will result from such a trial will lead to the extension of the system to all the wooded public domain.

FOREST CONDITIONS ON THE PLAINS AND PRAIRIES OF CANADA.

By Wm. Saunders, Director of the experimental farms of Canada, Ottawa, Ont.

[Read at World's Fair Congress, October, 1893.]

The plains of Canada, which extend from about sixty miles east of Winnipeg, Manitoba, to Morley, in the Northwest Territories, a distance of 940 miles, and from the United States boundary to, in most localities, an undetermined limit in the north, present throughout very varied conditions which influence the growth of trees.

In traversing the country on the great highway to the Pacific, the Canadian Pacific railway, wood growth is seen in every stage of development, from thrifty, well-wooded groves of poplar, box-elder, ash, elm, oak, and birch, to the comparatively stunted forms seen

in the bluffs as the treeless plains are approached. Some portions of the country east of Winnipeg are fairly well wooded, both in the valley lands as well as on the occasional limestone ridges which crop up at several points on the route. On the south side of some of the larger rivers, such as the Red river and the Assiniboine, dense woods, chiefly of poplar, sometimes extend for many miles, while the trees on the northern sides are frequently limited to small clumps or single specimens, and these confined to the immediate banks of the rivers. In the main, however, the great part of the country along the line of the Canadian Pacific railway, after leaving Winnipeg, is almost bare of trees until the first step or rise on the plains is reached, which is about 100 miles west. Then the country becomes more bluffy, and tree growth in many places shuts out the distant view. Here, in addition to poplar, oak, and others, the hardy form of the white spruce (*Abies alba*), which has not been seen along the route for 150 miles or more, appears again and is found growing thriftily on the light soils which prevail along the rapidly rising ground at this point. For 200 miles more the scene is very varying; at one time the whole country is park-like, with clumps of small trees thickly intervening between limited stretches of treeless prairie; then, again, trees become scarcer, and soon the prairie seems boundless and treeless. But beyond Balgonie, 341 miles from Winnipeg, trees along the railway line become a scarce commodity, and, excepting where a few dwarfed and stunted specimens fringe the margin of a watercourse, the traveller will often pass very many miles with no sight of woods or trees as far as the eye can reach, and this condition prevails for more than 500 miles.

The individual who forms his opinion of that country entirely from what he can see from the passing train will often reach most erroneous conclusions. A close examination reveals the fact that these plains, in many places, are not so continuous as they appear to be, but that here and there, separated by greater or lesser distance, are huge ravines or valleys, below the level of the plains, scooped out in bygone times by the forces of nature, of various depths and widths, often from 101 to 300 feet deep, and from half a mile to a mile or more in width, and along the bottom of these there usually runs a small stream of water, often diminished to a series of disconnected pools during the hottest parts of the summer, and swollen into a turbulent stream in the spring-time. In these coulees, protected from the sweep of the winds, and benefited by

the moisture which results from the gradual melting of accumulated snow in the spring and the running water in the bottom, trees thrive to such a degree as to astonish the beholder, and from many such localities the settler can obtain logs in abundance wherewith to construct his first dwelling-place, provide buildings for his stock, and firewood for his use during the winter months. Further, by journeying north of the railway track, across the treeless plains, at distances varying from 25 to 150 miles, trees in abundance are to be found everywhere all across the continent. These rarely form continuous woods for any great distance, but are mostly grouped in clumps and groves, with stretches of open land between them.

The hot winds which, during the summer months, blow northward from the dry and desert regions in the United States, extend into the Territories of Canada, exerting their parching influence to a greater or less degree as they move northward, but constantly weakening until their force becomes exhausted. This influence dies out at varying distances, from 100 to 250 miles from the boundary line, and as the limit is approached changes are seen in the aspect of the landscape: the grass becomes greener, clumps of shrubs and trees appear, at first insignificant and stunted, but shortly they become a prominent feature in the landscape, and within a few more miles the country becomes well wooded and watered. This wooded or partly wooded condition continues for a long distance north. For from 200 to 300 miles it is much the same as when first entered on, but beyond this the Government surveys have not yet extended, and our knowledge of the country is limited to the information obtainable from the Hudson Bay Company's officers located at the different trading posts in the interior and to the published observations of explorers who have, as a rule, followed mainly the course of the rivers in their travels. Mr. Wm. Ogilvie, a surveyor and explorer of the Department of the Interior, a most reliable observer, has, during the past seven years, made preliminary surveys of the greater part of the vast region north, and from his reports a few brief extracts will presently be submitted.

The recently constructed railway from Calgary, Alberta, on the main line of the C. P. R., takes the traveller 200 miles north of that town, or about 325 miles north of the United States boundary. By driving over the Athabasca trail 100 miles beyond this, Athabasca Landing is reached, the starting point of the system of inland navigation established by the Hudson Bay Company. From the Landing to Fort McPherson, at the mouth of the Peel river, a

few miles from the shores of the Arctic Ocean, the furthest point visited by their steamers, is by water travel 1,854 miles, and this established line is used by all travellers and explorers in that country as the basis for their work.

Of the valley of the Athabasca river from Athabasca Landing to Fort McMurray, 282 miles, Mr. Ogilvie says: "In the bottom of the valley there is much spruce and some poplar that would make fair lumber. On the uplands, as far as I saw, there were many places where a similar quality could be obtained. From Fort McMurray to Fort Smith, on Great Slave Lake (287 miles), there is much fine merchantable spruce. The same remark applies to the timber on Great Slave Lake and Mackenzie river (250 to 300 miles further). The timber in the valley of the Liard, one of the streams emptying into the Mackenzie, 1,260 miles by water from Athabasca Landing, deserves special mention, so many of the trees were of large size. All the way from the Mackenzie up to the forks of the east branch and Sicannie Chief river, a distance of nearly 450 miles by the streams, there are large extents of large and good spruce which would make better lumber than any other I have seen anywhere in the country. The balsam poplar, particularly, grows very large; on the east branch many trees were seen of that variety more than three feet in diameter at the ground. At Fort Nelson, 57 miles from the mouth of the Liard, there is a flat, thickly grown with spruce and poplar, where I selected a medium tree of the latter species, cut it down, and found the following dimensions: Diameter of stump, exclusive of bark, 29 inches; diameter, exclusive of bark, at first limb, 17½ inches; length from top of stump to first limb, 90 feet; number of rings of growth, 149." This tree was cut at a point 1,371 miles by river navigation north of Athabasca Landing, while the Landing is about 425 miles north of the United States boundary. From these brief extracts it will be seen that some trees attain goodly proportions very far north in Canada.

The present distribution and growth of trees over the immense area referred to in the coulees and bluffy ravines on the prairies and in vast tracts of wooded country in the interior have an important bearing on the future forest conditions of the plains and prairies of Canada. A general sentiment prevails among the settlers on the treeless plains in favor of tree-planting, and a strong desire is expressed on every hand for such trees as will grow and thrive to provide shelter for the home and for the stock, and to relieve the

monotony which attaches to treeless districts. Nearly all such tree-planting, to be successful, must begin with the native sorts, and in the seedling trees and tree seeds obtainable from these hardened denizens of the north we have the most suitable material for this work. On the experimental farm at Indian Head, Northwest Territories, which is located on the edge of that belt of dry country to which reference has been made, many useful experiments have been conducted in tree-planting during the past five years. The land selected for the experimental farm was a treeless tract of prairie. At first it was difficult to obtain sufficient quantities of young trees of native species grown in the country for planting, and large numbers were purchased from tree-growers in Northern Michigan, Illinois, and Nebraska, chiefly of box-elder, green ash, and elm; but in every instance these trees have proved tender and have been injured by the climate here, whereas trees of the same species transplanted from the adjacent valleys or grown from seed ripened there have proved entirely hardy. The idea that young trees having the greatest degree of hardiness can, as a rule, only be had by growing them from seed obtained as far north as possible is not new. Mr. Douglas, of Waukegan, Ill., has for many years had agents employed in collecting the seeds of such conifers as the blue spruce (*Picea pungens*), the Douglas fir (*Pseudotsuga Douglasii*), and the bull pine (*Pinus ponderosa*) as high up in the western mountains as the seed could be found, where the trees would be exposed to a degree of cold unknown in the valleys, and it has been abundantly proven that trees grown from such seed will endure with impunity climatic conditions which would destroy those grown from seed of the same species produced in the warmer valleys. It was not, however, as far as I am aware, generally supposed that this rule, so well known to apply to conifers which hold their foliage the year round, would be found to apply with equal force to deciduous trees. This sensitiveness to injury is not confined in its effects to the severest weather. During the autumn of last year I happened to visit the Indian Head farm on the way home from the Pacific coast and arrived there the day following a severe frost. I cannot now recollect the lowest temperature recorded the previous night, but it would probably be from 12 to 15 degrees Fahrenheit of frost. During the day I inspected two belts of box-elder trees from three to five feet high, one of which had been grown from young trees obtained from Nebraska and the other from seed collected in the neighboring valleys. The trees had lost none of their foliage, and

the difference in the effect of the frost on these two groups was quite striking. The Nebraska trees were all scorched, with the foliage drooping and partly withered, while the trees grown from Northwest seed remained fresh looking and uninjured. Similar difference in relative hardiness has been found to obtain in the elm, green ash, and mossy-cup oak, and I think there is no doubt, from the experience had, not only on the Northwest plains, but also in the other climates of Canada, that it is a law, almost universal in nature, that, to obtain the hardiest trees and shrubs, the seed from which they are grown must be matured at the northern limit of their growth, and that where this is done the natural northern limits of the growth of the species may be gradually extended. To test these points many thousands of young trees have been grown both from Eastern and Western seed, and tested at the experimental farms in Manitoba and the Territories; packages of the young trees have also been distributed to several thousand settlers in different parts of the country, and the general experience has established the correctness of the above conclusions. Acting on the information thus gained, and with a view to encourage tree-planting, there has been distributed during the past three years by the experimental farms more than five tons of tree seeds, all of which have been collected in the bluffs and valleys in Manitoba and the Northwest Territories. These have been distributed, free of cost, by mail to all applicants and have reached fully 10,000 homes. A large quantity has also been grown on the experimental farms. The young seedlings thus obtained have given great satisfaction, and there are now growing on a large proportion of the homesteads on the plains and prairies of Canada nursery plots of young trees from one to three years old, containing hundreds of specimens, which are being transplanted to permanent locations from year to year, as required, to form shelter belts for the dwelling and barns, for the vegetable and small fruit plantations, and to improve the appearance of the farms. In the course of four or five years more, many of the trees will bear seed and will thus furnish the material to enlarge the planting to any extent required, and supply also the wants of new settlers in the neighborhood.

Several hundred specimens of young trees of the white spruce of the East have been sent from the nurseries there to the experimental farms on the Canadian plains, but very few of them have survived, while a large number of young trees of the same species growing on the open prairie, on the first steppe on the plains, have

been transplanted to the experimental farms during the past three years, none of which have shown any indication of tenderness, and nearly all of them are doing well. Many thousand young seedling elms have been dug from under the larger native trees along the river valleys in the northwest, and planted in nursery plots on the western farms; a quantity has also been grown at the Central Experimental Farm in Ottaway from Northwest seed and distributed as seedlings. These have all made satisfactory growth and are proving to be admirably adapted to the climate. Young trees of the Banksian pine have been brought down from Prince Albert, 200 miles north, in the wooded districts, and have proven quite hardy on the plains. An assortment of young trees has also been obtained in the colder districts along the height of land on the north shore of Lake Superior, including the American larch, canoe birch, American mountain ash, and dwarf birch, and these also are doing well. When work was begun on the experimental farm in the Northwest, a large assortment, consisting of many thousand young trees and shrubs of all the hardiest sorts, were sent there for test and were planted, without shelter, on the open plains. A large proportion of these died the first year, and there are now not many survivors left to represent this first consignment. The most notable and valuable exceptions to this fatality are several species of strong growing poplar and willow from Russia, which seem to thrive in almost every situation, however exposed. The European white birch has also proven exceedingly hardy. The same may be said of the *Caragana arborescens*, or Siberian pea tree, which stands the most severe tests equally well with the hardiest natives.

As results of the work in tree-planting during the past five years, we can point to fine groves, shelter belts, and avenues of thrifty and rapidly growing trees on each of the experimental farms; also a large number of hedges of the same material, embracing in all 50,000 to 75,000 trees at each place. Along the western and northern sides of these farms shelter belts are planted 100 feet wide and from a mile to a mile and three-quarters long in each case. The trees in these belts are planted five feet apart each way. Large blocks have also been planted on other parts of the farms, at the same distance apart. In some of these the growth has already become so dense as to furnish favorable forest conditions in the way of shade, leaf covering of the soil, and the conservation of moisture and its accumulation by the collecting of

snow in winter, and the growth in future will probably be much more rapid than in the past. In these closely planted and thrifty belts, where the shelter is ample, other forest and fruit trees, which have proven tender on the exposed prairie, are being tried again, with promising results thus far. A portion of each farm has been enclosed by hedges made of those trees and shrubs which have proven hardiest, thus supplying shelter to long, narrow blocks of land for the growing of small fruits, vegetables, and other products. The intervening hedges are placed from 66 to 112 feet apart, and already, although the hedges are quite young, the advantages arising from shelter are apparent. On the experimental farm at Indian Head a rapid-growing shrubbery, Artemisia, has been found very useful in furnishing hedge shelter promptly, owing to its very rapid growth. This shrub was brought to America first by Prof. J. L. Budd, of the Agricultural College at Ames, Iowa, and has been distributed under the name of *Artemisia abrotans* var. *Tobolskiana*, or Russian Artemisia. Cuttings of this shrub root very promptly, and, planted in rows in the spring, will usually form a very useful protective hedge by the end of the first or second seasons.

From a careful examination of the results of the planting of all the trees and shrubs tested, there are now at both farms, including the natives, about 100 varieties which have proven hardy and are useful either for shelter, ornament, or forest cover. This work of selection and test will go on indefinitely, and it is expected that within a few years the number of hardy varieties will be doubled. An arboretum has been established at each farm, where specimen trees and shrubs will have space to develop their full proportions, as far as the climate will permit, and by the future study of these much information will be got as to the best uses and combinations which can be made of the individual species.